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# **SPACE PROCESSING APPLICATIONS PAYLOAD EQUIPMENT STUDY**

## **VOL. IIE. COMMERCIAL EQUIPMENT UTILITY**

DPD NO. 40  
DR NO. MA-04  
DCN NO. 1-3-21-00235  
CONTRACT NO. NAS 8-28938

JULY 1974

A. G. SMITH (EDITOR)



PREPARED FOR

GEORGE C. MARSHALL SPACE FLIGHT CENTER  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

BY

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## FOREWORD

Phase II documentation prepared for the Requirements and Concepts for Space Processing Payload Equipment Study under Contract NAS 8-28938 resulted in a three-volume report. These volumes are as follows:

- Volume I. Executive Summary
- Volume II. Technical
  - IIA. Experiment Requirements
  - IIB. Payload Interface Analysis
  - IIC. Data Acquisition and Process Control
  - IID. SPA Kit
  - IIE. Commercial Equipment Utility
- Volume III. Programmatic and Payload Accommodation

Volume II, Technical, is published as five sub-volumes in order to facilitate presentation of topical groupings of data.

Phase I documentation was previously documented in 1973 as three volumes under the title, Requirements and Concepts for Materials Science and Manufacturing in Space.

One feature of this study has been the close association between the NASA Shuttle Sortie Working Group on Materials Science and Manufacturing in Space and the study contractor, TRW Systems Group. The NASA-MSFC study COR, Mr. Kenneth R. Taylor, has provided TRW Systems Group with working group documentation and, in turn, has coordinated study task results into the activities of the working group.

The TRW Systems Group personnel who assisted in the preparation of Volume IIE are listed below:

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- Mr. J. L. Regar
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## 1. SUMMARY

Examination of commercial equipment technologies revealed that the functional performance requirements of space processing equipment could generally be met by state-of-the-art design practices. Thus, an apparatus could be evolved from a standard item or derived by custom design using present technologies. About 15 percent of the equipment needed has no analogous commercial base of derivation and requires special development. This equipment is involved primarily with contactless heating and position control.

The derivation of payloads using commercial equipment sources provides a broad and potentially cost-effective base upon which to draw. The derivation of payload equipment from commercial technologies poses other issues beyond that of the identifiable functional performance, but preliminary results on testing of selected equipment testing appear quite favorable.

During this phase of the SPA study, several aspects of commercial equipment utility were assessed and considered. These included safety, packaging and structural, power conditioning (electrical/electronic), thermal and materials of construction. In considering the impact of using commercial equipment in the Spacelab, it was found convenient to draw-up acceptance criteria which could be used in the analysis of the problem areas involved with specific items of equipment. These criteria were based in part upon certain assumptions of the Spacelab's operations which were taken in part from the referenced documents in Section 7. These assumptions do not in some instances necessarily represent present or future NASA plans. Changes in these are expected as the program progresses and these changes may in turn necessitate corresponding changes in the restrictions and requirements that have been developed.

In conjunction with the identification of the potential problems facing the use of commercial equipment, a series of approaches and solutions were identified. Also, several items of SPA payload equipment were analyzed in further detail to develop information regarding necessary modifications and tests and needed additional information from the manufacturer. Four manufacturers were contacted personally to discuss the applicability of their respective equipment items. This information obtained has been formulated into short Commercial Utility Surveys. These, along with the Commercial Item Surveys from the first year-long study\*, have been collected together in Section 6.

Requirements and Concepts for Materials Science and Manufacturing in Space Payload Equipment Study, Contract No. NAS 8-28938, July 1973.

## 2. INTRODUCTION

One of the key assertions of the previous study was that considerable advantage could be gained through incorporating into the SPA equipment inventory as much commercially available equipment as possible. A number of arguments in support of this assertion can be advanced; for example, most of the anticipated experiment functional requirements for SPA payloads can be satisfied by commercial equipment and design technologies; also the potential cost decrease which may be achieved through the use of commercially available equipment is considerable. Even though, at the outset, the use of such equipment promises significant advantages, a number of usage factors remain to be resolved. Specific factors include the following:

- Safety
- Packaging
- Structural
- Power Conditioning
- Thermal Control
- Materials of Construction

The list of commercial utility aspects can be broken into three categories. The first category includes the areas of packaging, structural, power conditioning and thermal. This group is concerned with questions related to the functional or operational characteristics of the individual equipment item. In this sense judgements and assessments concerning utility of a commercial piece of gear can be made, to a reasonable extent, by considering several typical equipment items in light of their functional and operational characteristics. By example, the functional and operational characteristics of tube furnaces do not vary much from one manufacturer to another, so that a tube furnace produced by any one of several manufacturers can be used to assess such factors as the thermal, power and structural impacts upon the SPA payload. Certain aspects of materials of construction such as susceptibility to deposits or shatterability also fall into this category. The functional or operational characteristics and requirements of some of the commercial equipment items may require that certain components, such as lenses, be constructed of non-shatterable material. In this area also, assessments can be made on the potential impact of commercial equipment



on the SPA payload through consideration of a typical equipment item chosen from any of several manufacturers.

In contrast, the second category concerns questions relating to materials of construction, such as outgassing and flammability, which are to a much greater degree subject to variations from one manufacturer to another. These questions will, in most cases, have to be considered on an individual basis with respect to each specific equipment item and each specific manufacturer.

The third category is concerned with questions of safety. When an issue within the first two categories presents a potentially hazardous situation which must be readily accepted, the problem must be treated from the point of view of safety. As an example, since high voltage equipment is necessary for performance of SPA mission requirements, suitable steps will be required to assure crew and vehicle safety.

Assessment of commercial utility considerations falling within the first category is closely associated with the subsystem interface trade studies which are presented in Volume II-B, "Payload Interface Analysis (Power, Thermal and EMC)". Coordination of the commercial utility assessment and the interface trade studies was required to optimize the information and results of the two efforts. Whenever possible, equipment considerations and interface studies have considered the same equipment items. A matrix identifying the problem areas associated with each equipment item was prepared and is presented in Table 1. Initially, only the major problem areas were identified, with no rating factor applied. An update of the matrix may be made during future studies to include some relative assessment of the potential problems together with a refinement of the problems to be considered.

Initial efforts directed primarily at the second category of potential problem areas have to do with adopting a set of acceptance criteria as a basis for assessing commercial equipment utility.

# FOLDOUT FRAME

SPA PAYLOAD EQUIPMENT	SAFETY			PACKAGING			
	HIGH VOLTAGE	MICROBIOLOGICAL CONTAMINATION	TOXIC SUBSTANCE	HIGH PRESSURE	MONITORING OF COMPOSITION	ABUSE	OTHER
ATMOSPHERIC COMPOSITION Fluid Supply System Gas Chromatograph High Vacuum Pump Residual Gas Analyzer					•	•	
BIOLOGICAL PROCESS EQUIPMENT Continuous Flow Electrophoretic Column Isoelectric Focusing Unit pH Monitor Stationary Electrophoretic Column	•	•	•			•	•
COOLING EQUIPMENT Directional Solidification Unit				•		•	
DATA ACQUISITION AND CONTROL EQUIPMENT Data Acquisition Unit Data Control Unit Electro-Optical Imaging System Oscilloscope Time Lapse/High Speed Camera						•	
ENCLOSURES/FURNACES Chest-General Purpose Enclosure Glove Box Gradient Furnace Hot Wall Furnace (1800°C) Hot Wall Furnace (1200°C) Thermal Oven				•			•
HEATING UNITS Electron Beam Source Laser Source RF Induction Coils Resistance Heater (Contact) Resistance Heater (Non-Contact)	•	•					
MANIPULATION AND DISPENSING UNIT Zone Refiner	•					•	
MIXING AND DISPERSAL UNIT Mechanical							
OPTICAL EQUIPMENT Dark Field Illuminator Dye Laser/Flash Lamp IR Spectrometer Laser Optical Scattering Monitor UV-VIS Spectrometer	•						
POWER CONDITIONING High Voltage (5 kV) High Voltage (17 kV) Low Voltage/High Amp RF Induction (2 kW-2 MW)	•	•					
TEMPERATURE MEASUREMENT AND CONTROL IR Pyrometer T-v-Color Pyrometer							

Note: All equipment items not listed were considered but did not have any attendant major problem.

FOLDOUT FRAME 2

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**Table 1. Problem Area Assessment of SPA Payload Equipment Utility**

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### 3. ASSESSMENT

### 3. COMMERCIAL EQUIPMENT UTILITY ASSESSMENT CONSIDERATIONS

#### 3.1 SAFETY

Safety as used here will be considered in an operational sense since structural, outgassing and flammability are treated as separate items. Of concern would be undue hazards to the crew associated with use of commercial equipment. Use of interlocks, over temperature and redundant control features will be required irrespective of the equipment derivation sources. While the considerations of structure, outgassing, etc., are treated separately, it must be recognized that the subject of safety is directly or indirectly affected by every other area of concern considered in the following sections. However, with the exception of the closed loop environmental system, the positive preventative measures necessary to assure safety to the crew and vehicle are not greatly different from those of a ground-based laboratory.

The subject of safety is directly or indirectly affected by every other area of concern that is considered in the following sections.

- In the area of power conditioning there is always a potential hazard due to high voltages. The necessary precautionary measures are well understood by both the manufacturing and technical individuals who associate themselves with high voltage equipment. Application of these measures will necessarily be standard operating procedure for Spacelab activities.
- In the area of thermal control, there is danger to both the crew and other equipment in the case of high temperatures.
- With regard to materials, there are several potential safety hazards such as toxicity, corrosivity, flammability and outgassing.
- It is obvious, therefore, that safety is tied in closely with the previously mentioned problem areas. If they are handled properly, the safety concerns should be at a minimum.

A major safety concern lies in the area of the main operating subsystems: electrical, environmental control, thermal control. It is desirable to maintain these subsystems separately between the Spacelab and

and Shuttle Orbiter in order to provide a degree of redundancy. In this manner there would be backup in case a subsystem should fail.

In the critical area of environmental control, an added safety feature would be desirable. This would consist of some means by which the total Spacelab atmosphere could be replaced quickly in the event of contamination. This contamination could stem from several sources:

- outgassing
- pressure vessel failure
- sample escape
- smoke due to fire

Another area of safety concern lies in the area of high voltage and electrical shock. There are several ways to reduce the hazards:

- marking high voltage locations
- incorporating electrical interlocks
- automatic short circuit features
- automatic overload shut-off

All equipment must be designed to withstand anticipated accelerating forces.

- Each item must withstand 3.0\*g.
- All cables, pipes, electrical wires and connectors to such should be restrained to withstand 3.0\* g.
- Equipment mountings to Spacelab should be designed to withstand 9.0\*g.

It will be safer to have equipment that is mounted and checked out prior to launch rather than after reaching orbit.

There are several safety concerns regarding the materials of construction of the equipment items. If it is impossible to eliminate the offending materials, provisions must be made for reducing or eliminating the hazards. Some of the hazards are listed below.

- Fire due to flammable materials
- Toxicity due to outgassing of materials

\*These and other specific values, identified by an asterisk, are subject to change as Spacelab guidelines are updated or changed.

- Glass breakage or other shatterable materials.
- Materials that are susceptible to microbiological contamination.
- Materials that decompose or corrode readily in the anticipated space environment.

Special consideration will be required for the safe handling of gases or liquids by such methods as flow restrictions, relief valves or venting requirements.

### 3.2 PACKAGING AND STRUCTURAL

Equipment items should be repackaged as necessary prior to launch and then mounted on appropriate supporting structures to eliminate the need for mounting operations in space.

Packaging design must take into account the problem of cooling the equipment.

- Most equipment items must be spaced so that it will be possible to use forced convection cooling.
- It may be found necessary to provide low thermal resistance contact to support structures that have a high thermal conductivity (cold plating).

The problem of abrasion occurring either between components of an apparatus or between neighboring items must be eliminated. This is important in order to prevent the formation of paint flakes, powders, or other aerosol materials.

It may be necessary, within certain equipment items, to have internal components modified so that they will perform well under low-gravity conditions.

Small detachable accessory items must be secured by a lanyard and must be stored in a drawer or other secure place when not in use.

Packaging should be designed to be consistent with use at normal room temperature [18-29°C (65-85°F)]\* and at a normal pressure level of 14.7\* psi (80% N<sub>2</sub>, 20% O<sub>2</sub>)\*.

Packaging/structural designs must be consistent with anticipated acceleration loads of 3.0\* g on launch and reentry or 9.0\* g for crash landings.

- Equipment items must be designed to withstand internal accelerations of 3.0\*g.
- Equipment mountings to the supporting structures must be capable of withstanding acceleration loads of 9.0\*g.
- After packaging geometry design has been completed and modifications made, simple acceleration tests should be performed to qualify each individual commercial item.

It will be necessary to estimate the maximum amplitude and frequency spectrum of the anticipated vibration loads from Shuttle design, and then vibration tests should be designed.

Packaging of hydraulic and pneumatic systems will require the design and performance of special testing.

### 3.3 POWER CONDITIONING (ELECTRICAL/ELECTRONIC)

The available power from the host vehicle versus the power requirements will be of major concern.

- Voltage levels - 28 VDC\*, 110 VAC\*, 220 VAC\*
- Voltage forms - DC, 60 Hz\*, 400 Hz\*, 1800 Hz\*
- Power levels
- Power quality (ripple factor)

The problem of preventing any power source overloads must be considered.

Electromagnetic compatibility (EMC) is a major concern in the use of commercial equipment.

- Equipment must not produce electromagnetic interference (EMI) with Shuttle avionics.
- Equipment must not produce EMI with other experiment apparatus.
- EMC becomes a critical issue at chassis points.
- EMC testing must be designed and then performed after the assembly of the Spacelab for each flight.

Any other interface problems between the instruments must be identified and resolved.

Many solid-state circuits use low voltage direct current, and since



power is lost in the conversion of DC to AC, it may be deemed practical to convert many instruments to DC operation.

### 3.4 THERMAL

Temperature variation susceptibility must be examined to determine the criteria that must be imposed to keep the equipment within acceptable ranges of temperature and also to determine what happens to the reliability if this range is exceeded.

The magnitude of the thermal load must be considered with regard to the commercial equipment. There are two types of thermal loads:

- Functional loads -- where the purpose of the equipment item is to produce heat itself, such as to heat up a sample.
- Operational loads -- those are due to the heat production of the equipment merely because of its being in an operating condition.

Due to the absence of free convection air cooling in space, provisions must be incorporated in the design to provide cooling for the equipment.

- Fans may be used to force the heat away from the area of heat production.
- Heat pipes may be used by providing low thermal resistance to high thermal conductivity mechanical supports.
- Active fluid cooling will be required for some apparatus.

### 3.5 MATERIALS OF CONSTRUCTION

Outgassing of materials must be studied and limitations and controls set up.

- May cause contamination of the Environment Control System (ECS) which could become a toxicity problem to the crew.
- May cause deposits to form on surfaces which may cause interference with the proper function of certain equipment, such as optical apparatus.
- All materials should be tested in a standard environment (80% N<sub>2</sub>, 20% O<sub>2</sub>)\* at 14.7\* psi of pressure. Tests may be performed at a component level and/or at an integrated level.

- Automatic atmospheric monitoring, to test for outgassed materials, will be desirable from a safety standpoint.

Flammability of materials must be considered and elimination of offenders must be made.

- Flammability in an 80% N<sub>2</sub>, 20% O<sub>2</sub>\* atmosphere, at a pressure level of 14.7\* psi and at predetermined maximum temperature must be considered
- Federal Aviation Administration requirements will probably be adequate and all materials should be tested.

Corrosivity must be studied and substitutions made for offending materials.

Shattering and breaking of materials must be studied and substitutions made as required.

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4. ACCEPTANCE  
CRITERIA

## 4. ACCEPTANCE CRITERIA

### 4.1 INTRODUCTION

In considering the impact of using commercial equipment in the Spacelab, it was found convenient to draw-up acceptance criteria which could be used in the analysis of the problem areas involved with specific items of equipment. For the Spacelab it appears reasonable and appropriate to relax to some degree the requirements placed on equipment and materials in previous manned spacecraft programs. The reasons for allowing this relaxation are dependent on assumptions regarding the planned operation of the Spacelab, two of the principal reasons are the use of a two-gas system and a physical isolation capability/separation of the Spacelab from the Shuttle systems.

Discussed below are the assumptions made in drawing up the criteria, followed by the suggested restrictions and requirements to be placed on commercial equipment and materials to be used in the Spacelab.

### 4.2 ASSUMPTIONS OF SPACELAB OPERATIONS

The following assumptions, taken in part from the referenced documents, are made in regard to the operation of the Spacelab. These assumptions do not in some instances necessarily represent present or future NASA plans. Changes in the assumptions are expected as the program progresses and these changes may necessitate corresponding changes in the restrictions and requirements of the following section.

a. The main operating systems (electrical, environmental control and thermal control) of the Spacelab will be separable from those of Shuttle. This separation of functions will allow use of commercial equipment with fewer modifications, and will be a safer mode of operation regardless of the type of equipment operating in the Spacelab.

b. An environmental control system will provide a two-gas atmosphere (80% N<sub>2</sub>, 20% O<sub>2</sub>)\* at 14.7\* psi, 40-60% relative humidity, at 65-85°F\* (18.3-29.4°C)\*. A gas purification and monitoring (temperature, composition, aerosols, etc.) system will provide a class 100,000 environment [1] continuously from the pre-launch period until the end of the mission. An emergency gas supply system will exist, to be actuated manually from within the Shuttle, which can completely replace the Spacelabs atmosphere in case of fire, smoke or accidental release of toxic compounds.

c. Electrical power will be provided from fuel cells with controls from within the Spacelab.

d. Acceleration levels will be 3.0\* g maximum (at take off and re-entry) and 9.0\* g in case of a crash landing.

e. The principal vibrational frequencies will be in the range 20-2000\* Hz at a maximum of 14\* g (rms) composite vibrational level.

f. All major items of equipment will be mounted in the Spacelab and checked out prior to launch.

#### 4.3 RESTRICTIONS AND REQUIREMENTS ON COMMERCIAL EQUIPMENT

Based on the assumed mode of operation for the Spacelab, as given above, the following restrictions and requirements are taken to represent acceptance criteria for commercial equipment. Many of these provisions have been selected from NASA documents found in the references.

a. Materials which are flammable, burn, give off smoke or decompose in air at 14.7\* psi below 200°C (392°F)\* will not be used. The odor rating [2,3] at 68 C (155 F)\* must be less than 25. Thermal outgassing at 68 C (155F) must be less than 100\* µg/g of sample and carbon monoxide must be less than 25\* µg/g of sample.

b. Titanium and titanium alloys will not be exposed to liquid oxygen or to oxygen gas at a partial pressure greater than 3.5\* psi.

c. Materials which are toxic, give off noxious fumes or dust, or are otherwise hazardous at temperatures below 200°C\* (392°F)\* will not be used. If fluids produce toxic fumes, measurements of total leakage will be performed.

d. Cadmium and cadmium compounds will not be used in areas where the temperature may be greater than (230°C)\* (446°F)\*.

e. Beryllium and beryllium compounds must be restricted to applications where no corrosion, erosion, flaking, or powder formation are expected.

f. Mercury and mercury compounds must be restricted to applications where no immediate contact with the Lab atmosphere is possible.

g. Cadmium, molybdenum, and zinc will not be used in electrical contacts.

h. Ethylene glycol must contain a silver chelating agent when used in areas where free silver is present.

i. Use of radioactive materials must meet Atomic Energy Commission requirements [4].

j. Carcinogenic materials will not be used unless present health requirements [5] are met.

k. Silver plated copper conductors with fluorocarbon coating will not be used where there is a possibility of contact with moisture.

l. Materials must be non-nutrient to fungus growth or protected by a coating.

m. Lubricants will be selected after testing for each specific application [6].

n. All materials used in candidate commercial equipment for which qualifying data is not available must be tested.

o. After equipment has been prepared for mounting and check out in the Spacelab acceleration and vibration tests (TBD) must be carried out to qualify individual commercial items.

p. All connectors must withstand 3.0\*g; all electrical wires, cables, and tubing must be secured to withstand 3.0\*g. Vibration test requirements (TBD) will also be met.

q. Abrasion (internal and between adjacent items) must be prevented to avoid production of paint flakes, powder, or other aerosols.

r. Small detachable items must be secured by a lanyard and kept in a secure place when not in use.

s. Equipment must be marked at approximate locations to warn of hazardous conditions.

t. Flow restrictions and relief valve or venting requirements (TBD) for handling gases and liquids must be met.

u. Equipment must be compatible with maintaining a class 100,000 atmosphere, with a class 10,000 atmosphere at localized work stations as required.

v. All glass or other shatterable material will be removed or provisions will be taken for positive protection against breakage.

w. Each commercial item will be mounted in the Spacelab such that the mounting will withstand 9.0\*g.

x. Each equipment item will be checked for electromagnetic interference with Shuttle avionics and with other experiments.

## 5. APPROACHES/SOLUTIONS

In conjunction with the identification of the potential problems facing the use of commercial equipment in the SPA payload, a series of possible approaches and solutions have been identified.

Specific recommendations with respect to thermal control, power requirements and EMC analysis will result from the interface trade studies as well as the commercial equipment utility. Implementation of the recommendations is anticipated to occur at the following three levels:

- o Vendor level
- o Intermediate level
- o Integration level

The key elements relating to these areas are shown schematically in Figure 1.

Some possible approaches to the solution of these problems are indicated below:

### 5.1 STRUCTURAL/PACKAGING

The modifications to the structural aspects and packaging of the SPA payload equipment has impact at several levels. At the component level, some internal parts may require modification or additions for the following: structural support, isolation against shock and vibration, conduction paths to assure adequate heat transfer. In the case of fragile heating elements for the furnaces, for example, this may involve repackaging only for launch or landing, while for other components a permanent modification will be required.

At the equipment item level, modifications to the packaging or mounting arrangement will be required. Among the key issues in this regard will be that of EMC and thermal control requirements. The questions of electrical bonding, shielding, etc., will be addressed in the subsystems interface studies, as will questions of conduction and convection cooling. Many of the equipment items are available with a rack-mounting option, in which the item is cantilever mounted at the front panel. This will not be sufficient in most cases, so that where this exists in commercially available equipment, modifications to the equipment will be required. Along with



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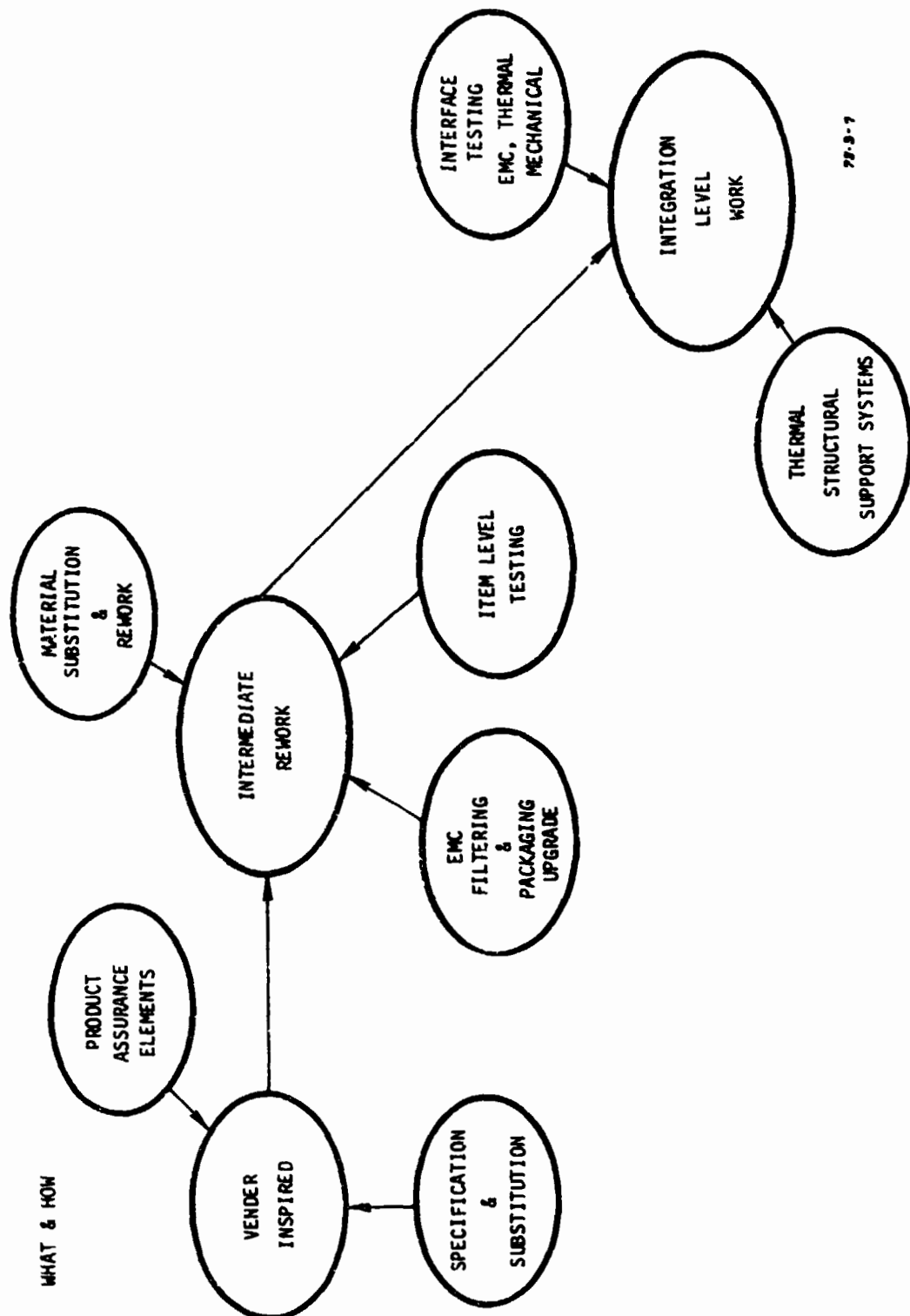


Figure 1. Key Elements Related to Implementation of Recommendations.

such modifications, it will be necessary, through design efforts at the systems level, to incorporate the techniques required to allow for support through means other than just front panel mounts. Roller- to track-mounted equipment concepts (also commercially available) should aid in this requirement.

## 5.2 POWER CONDITIONING

To a large degree, questions relating to the electrical power requirements and distribution have been addressed in the subsystem interface studies. Required modification of commercial equipment with respect to power conditioning is expected to take place at the vendor level or at the intermediate level, with subsequent testing at the integration level, since such modifications requirements readily fall within the scope of analysis. Modifications and testing for EMC requirements are expected to occur at all three levels. Here again, specific requirements and recommendations have resulted from the subsystem interface studies and are contained in Volume II B, "Payload Interface Analysis (Power/Thermal/Electromagnetic Compatibility).

## 5.3 MATERIALS OF CONSTRUCTION

Fixes applied to problems of flammability and outgassing of the materials of construction of commercial items involve testing materials of construction (where existing data is insufficient or lacking entirely), control of materials at the vendor through management, traceability and specifications, and replacement or removal (in the case of undesirable platings and coatings) at the intermediate level. As stated, many of the problems will be unique to a particular manufacturer so that the remedies applied will necessarily be determined on an item by item basis.

## 5.4 THERMAL CONTROL

With respect to commercial equipment utilization, modifications required will typically involve the additions of heat sinks or dissipators to critical components within the equipment items at the vendor level or at the intermediate level followed by testing at the integration level. Key to this issue will be the coupling of the structural and packaging concepts together with the subsystem interface thermal control studies.



## 6. EQUIPMENT LIST - IMPACT UTILIZATION STUDY

The equipment found in Table 2 below were selected from Volume IIB of the previous study\* as specific items for determining the impact of equipment acceptance criteria on their utilization in the Spacelab. Because an approved NASA specification for equipment and material utilization in Spacelab did not exist, a set of in-house criteria, drawn largely from existing NASA documents, have been used in making the assessment. The equipment on the list were selected with the following considerations in mind: (1) the equipment should be representative of a type important to the success of future SPA missions, (2) possible problem areas may exist for Spacelab utilization, (3) the equipment should be complex, being composed of a large number of diverse materials and operating with a large number of functions, and (4) data availability. All items are classified as Commercial except for the continuous flow electrophoretic column, which is a Commercial Design Technology and Components item and is considered of sufficient importance to warrant inclusion.

TABLE 2. EQUIPMENT LIST

- Gas Chromatograph
- Continuous Flow Electrophoretic Column
- pH Monitor
- Freezer/Refrigeration
- Data Acquisition and Process Control
- Chest - General Purpose Enclosure
- Hot Wall Furnace (1800°C)
- Dye Laser/Flash Lamp
- High Voltage (5kV) Power Conditioner
- IR Pyrometer

As a starting point, the Commercial Utility Surveys that were made during the initial study\* were re-examined by the subsystems specialists, and minor changes were made wherever necessary. After examining these surveys and also pertinent company specification documents, required

\*Requirements and Concepts for Materials Science and Manufacturing in Space Payload Equipment Study, Vol. IIB, DCN No. 1-2-21-00172. July 1973

additional information was specified and modifications and tests were proposed.

Since the purpose of this task was merely to give an introductory survey of the potential problem areas, four items were chosen for further inquiry. Representatives were personally contacted regarding these four items, and the additional information obtained was compiled into short Commercial Utility Surveys. These are typical of the whole group and the information obtained for each are representative of the respective classes. As the studies progress in this area, more detailed analyses will be necessary. However, these surveys may serve as an initial foundation upon which to build a plethora of data regarding commercial equipment utility.

Each of the equipment items are considered separately in the following sections.

#### 6.1 GAS CHROMATOGRAPH

6.1.1 Commercial Item Survey Data - Gas Chromatograph for atmospheric composition determination.

NAME:

Basic (TM) Gas Chromatograph.

SUPPLIER:

Carle Instruments, Inc.  
1141 East Ash  
Fullerton, California 92631  
Phone: (714) 879-9900

MODEL NUMBERS:

Model 8001, plus Model 415X (X-1, 2, 3, 4) Valve Minder  
Model 4201 Valve Actuators (4), Model 4400 Programmed Attenuator  
Model 2011 Micro-Switching Valve, Model 2020 Micro-Switching  
Valve and Model 6639 Pressure Regulator. Helium or neon supply  
necessary for carrier gas. Data storage or recorder output to  
be provided. If the cabin temperature has a large variation  
[ $\sim 10^{\circ}\text{C}$  ( $18^{\circ}\text{F}$ )] during the measurement, positive temperature  
control to the columns may have to be provided, but it is not  
anticipated as a problem.

**PERFORMANCE SPECIFICATIONS:**

- Accuracy -  $\pm 0.5\%$
- Sensitivity - parts per million (ppm)
- Gases detected - CO, CO<sub>2</sub>, N<sub>2</sub>, Ar, O<sub>2</sub>, CH<sub>4</sub>
- Sample size - 1 mm (0.04 in)
- Repetitive sampling time - 5 to 60 min.

**DATA OUTPUT:**

Data output is in the form of a voltage shift with time. This is usually presented on a strip chart recorder, but it may be magnetically recorded for later playback. Since the main function of this system is to monitor the atmospheric composition of an enclosure, real-time output is desirable.

**POWER:**

Less than 300 W when in use (115 V - 60 Hz) - Intermittant operation.

**WEIGHT:**

Approximately 25 kg (55 lb), total system - basic unit is 10 kg (22 lb).

**VOLUME:**

18500 cm<sup>3</sup> (1100 in<sup>3</sup>)  
[43 cm (17 in) x 33 cm (13 in) x 15 cm (5 in)]

**PACKAGING/MOUNTING:**

Unit is metal enclosed, countertop mounted.

**COST:**

Basic unit (Model 8001) is \$675. Total system cost is \$2500, excluding recorder or other data monitoring units.

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:**

Slight repackaging required to convert system for rack or modular mounting. In addition, the carrier gas flow detector (normally a soap bubble meter) must be changed to a turbine vane-type or equivalent for low gravity operation.

**SHIPPING, STORAGE, HANDLING CONSIDERATIONS:**

None.

ADDITIONAL COMMENTS:

This system, with appropriate columns, may also be used in the area of chemistry of fluids for reaction products identification.

6.1.2 Commercial Item Survey - Event actuator, to provide programmable function actuation commands to the valves on the Gas Chromatograph.

NAME:

Valve Minder (TM)

SUPPLIER:

Carle Instruments, Inc.  
1141 East Ash  
Fullerton, California 92631  
Phone: (714) 879-9900

MODEL NUMBERS:

4151, 4152, 4153, 4154

PERFORMANCE SPECIFICATIONS:

Dual-channel drum-timer, 3 functions and 6 or more events in channel one; one function and 2 or more events in channel two. Includes a total of 18 event markers. Model 4151 has a cycle time of 60 minutes, 4152 - 30 minutes, 4153 - 15 minutes, and 4154 - 5 minutes.

DATA OUTPUT:

Data output is an electrical actuator signal(s).

POWER:

172 W (115 V - 60 Hz, 1.5 A) - Intermittant operation

WEIGHT:

Approximately 4 kg (8.8 lb)

VOLUME:

788 cm<sup>3</sup> (50 in<sup>3</sup>)  
[15 cm (6 in) x 10 cm (4 in) x 3-7.5 cm (1.2-3 in)]

PACKAGING/MOUNTING:

Metal enclosed, countertop mounting

COST:

\$325



## MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:

Slight repackaging required to convert apparatus for rack or modular mounting. In addition, electrical interference isolation to main power bus is required.

## SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

## ADDITIONAL COMMENTS:

This item may be useful for other systems where timed functions and events are required (e.g., chemistry of fluids).

6.1.3 Commercial in Survey Data - Gas pressure regulator to supply carrier gas to the Gas Chromatograph columns.

## NAME:

Pressure Regulator

## SUPPLIER:

Carle Instruments, Inc.  
1141 East Ash  
Fullerton, California 92631  
Phone: (714) 879-9900

## MODEL NUMBER:

6639

## PERFORMANCE SPECIFICATIONS:

This regulator must regulate the pressure from 0 to 414 KPa (60 psig) from a pressure source of up to 21 MPa (3000 psig). Regulation must be constant to  $\pm 0.1\%$  or better at any pressure setting.

## DATA OUTPUT:

Data output will be in the form of a pressure readout.

## POWER:

None.

## WEIGHT:

Not available.

## VOLUME:

Not available.

PACKAGING/MOUNTING:

This item normally mounts on the carrier gas supply cylinder.

COST:

\$72

MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:

This item may need to be modified: (a) to accommodate gas storage system; (b) to be able to regulate more than one carrier gas (i.e., He and Ne); (c) to insure that over-pressurization and concomitant safety hazards are eliminated; and (d) for automatic operation.

SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

ADDITIONAL COMMENTS:

This item may require the most extensive modification from the standpoint of utilization of a commercial product. It should, however, find many applications in other research areas.

6.1.4 Commercial Item Survey Data - "programmable signal attenuator to insure that each species comprising the atmospheric composition remains on scale during the analysis by the Gas Chromatograph.

NAME:

Programmed Attenuator

SUPPLIER:

Carle Instruments, Inc.  
1141 East Ash  
Fullerton, California 92631  
Phone: (714) 879-9900

MODEL NUMBER:

4400

PERFORMANCE SPECIFICATIONS:

This item has provisions for selecting the attenuation level for up to six species being monitored. The attenuation level are preset and have values of 1, 5, 25, 100 and 500, plus provisions for blanking out completely any unwanted peaks. The selection is governed by the event actuator (Valve-Minder, Models 4151, 4152, 4153 and 4154) which sequences the alternator.

DATA OUTPUT:

The data output consists of the signal from the gas chromatograph, appropriately attenuated.

POWER:

Approximately 15W (115 V - 60 Hz). Intermittant operation.

WEIGHT:

Approximately 4 kg (8.8 lb)

VOLUME:

1050 cm<sup>3</sup> (65 in<sup>3</sup>)

[15 cm (6 in) x 10 cm (4 in) x 7 cm (2.8 in)]

PACKAGING/MOUNTING:

Metal enclosed, countertop mounting.

COST:

\$245

MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:

Slight repackaging required to convert the apparatus for rack or modular mounting. In addition, electrical interference isolation to main power bus may be necessary.

SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

ADDITIONAL COMMENTS:

None.

6.1.5 Commercial Item Survey Data - Switching valves for series by-pass column switching plus back-flush of Gas Chromatograph.

NAME:

Micro Volume Switching Valves.

SUPPLIER:

Carle Instruments, Inc.  
1141 East Ash  
Fullerton, California 92631  
Phone: (714) 879-9900

MODEL NUMBERS:

Models 2011 and 2020.

**PERFORMANCE SPECIFICATIONS:**

The use of these valves allows greater sensitivity in detection of trace contaminants, speeds up the sample elution time and allows separation of sample components requiring two different columns for separation. Model 2020 allows series by-pass column switching, which is necessary to separate, for example,  $\text{CO}_2$  from  $\text{O}_2$  and  $\text{N}_2$ , and Model 2011 reverses the carrier flow in the column to enhance trace contaminant detection and to insure that a material balance of the analyzed gases can be made.

**DATA OUTPUT:**

There is no data output from these valves. Proper operation will be evidenced by output from the main gas chromatograph system.

**POWER:**

No power required. The valves are actuated by the valve actuator (Model 4201).

**WEIGHT:**

Approximately 1 kg (2.2 lb).

**VOLUME:**

182  $\text{cm}^3$  (11  $\text{in}^3$ )

[9 cm (3.5 in) x 4.5 cm (1.8 in) x 4.5 cm (1.8 in)]

**PACKAGING/MOUNTING:**

Metal enclosed body mounts to main gas chromatograph system.

**COST:**

Model 2011 - \$250

Model 2020 - \$265

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:**

Slight repackaging may be required to accommodate valve to rest of gas chromatograph system.

**SHIPPING, STORAGE, HANDLING CONSIDERATIONS:**

None.

**ADDITIONAL COMMENTS:**

None.

6.1.6 Commercial Item Survey Data - Valve actuator to provide valve drive open/close operations when commands are given by the event actuator to the valves of the Gas Chromatograph.

NAME:

Valve Actuator

SUPPLIER:

Carle Instruments, Inc.  
1141 East Ash  
Fullerton, California 92631  
Phone: (714) 879-9900

MODEL NUMBER:

4201

PERFORMANCE SPECIFICATIONS:

This item is a motor driven, gear reduced actuator coupled to the valve. The actuator is coupled to the valve by an adjustable cam system for precision alignment. Valve switching must be accomplished within 0.5 seconds to reduce tailing and increase accuracy and sensitivity.

DATA OUTPUT:

There is no direct data output. Successful actuation will be detected by proper response of the main atmospheric composition analyzer system.

POWER:

58 W (115 V -60 Hz, 1.5 A) - Intermittant operation.

WEIGHT:

Approximately 1 kg (2.2 lb)

VOLUME:

125 cm<sup>3</sup> (8 in<sup>3</sup>)  
[5 cm (2 in) x 5 cm (2 in) x 5 cm (2 in)]

PACKAGING/MOUNTING:

Metal enclosed, mounted to main gas chromatograph by side brackets.

COST:

\$140

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:**

Slight repackaging may be required depending on total system configuration. Electrical isolation required to prevent interference to the main power bus.

**SHIPPING, STORAGE, HANDLING CONSIDERATIONS:**

None.

**ADDITIONAL COMMENTS:**

This item may be utilized in other research areas where remote valve actuation is required.

**6.1.7 Modifications and Tests**

- Electrical power conversion to 28VDC or 110V-400Hz.
- Sampling input lines from experiments.
- Besides thermistor detector, another more sensitive detector (in series or parallel) may be desirable to detect impurities.
- Rack mounting for all items, tubing and wires secured to withstand 3.0 g.
- Recorder pen system.
- Carrier gas flow meter.
- Forced air cooling.
- Particles in column separators may effect separation differently in 0-g.
- Acceleration test at 3.0g, vibration tests, mountings test at 9.0 g.
- Outgassing test of complete system
- EMC tests.
- Removal of metal enclosures to enhance air cooling when rack mounted.

**6.1.8 Required additional information**

- Cost of modifications and tests
  - a. factory
  - b. NASA
- List toxic, flammable, shatterable, or otherwise possibly dangerous materials. A complete list of construction materials from the manufacturer would be desirable.

- Recorder lubricants
- Thermal heat transfer within column 1-g versus low-g.

## 6.2 CONTINUOUS PARTICLE ELECTROPHORESIS SYSTEM

This is a non-commercial item that deserves particular consideration and is made by Beckman Instruments (includes buffer curtain separation chamber and electrodes, separated-components collection system, buffer circulation system, and electrode rinse circuit).

### 6.2.1 Modifications and Tests

- Pumps require electrical power conversion to 28VDC or 110V - 400 Hz.
- Chamber mounted to withstand 9.0 g.
- Mount electrode rinse and buffer reservoirs, coolant coils, coolant lines, buffer and electrode rinse pumps and lines to withstand vibration and 3.0 g.
- Acceleration test at 3.0 g, vibration tests, mountings tests at 9.0 g.
- Outgassing test of complete system.
- EMC tests.

### 6.2.2 Required Additional Information

- Cost of modifications and tests
  - a. factory
  - b. program contractor
  - c. NASA
- List of toxic, flammable shatterable, or otherwise potentially dangerous materials; a complete list of construction materials is desired.

## 6.3 PH MONITOR

6.3.1 Commercial Item Survey Data - PH monitor to be used to monitor the pH of solutions which may undergo H<sup>+</sup> or OH<sup>-</sup> variations during the process.

NAME:

pH Analyzer

SUPPLIER:

Beckman Instruments, Inc.  
Process Instruments Division  
Fullerton, California 92634

**MODEL NUMBER:**

Model 941 (including pH amplifier/transmitter, pH indicator, LAZARAN reference electrode, glass electrode, thermocompensator, and series three stainless steel submersion assembly).

**PERFORMANCE SPECIFICATIONS:**

- Range - 0 - 12 pH units
- Spans - 2, 5, or 10 pH units
- Stability -  $\pm 0.02$  pH units
- Ambient temperature range -  $-7$  to  $50^{\circ}\text{C}$  ( $19$  to  $122^{\circ}\text{F}$ )
- Liquid temperature range -  $0$  to  $100^{\circ}\text{C}$  ( $32$  to  $212^{\circ}\text{F}$ )
- Ambient temperature coefficient - less than  $\pm 0.002$  pH units/ $^{\circ}\text{C}$ , with manual or automatic compensation.

**DATA OUTPUT:**

Output is in form of a voltage shift ( $0 - 10$  or  $100$  mV or  $0 - 1$  or  $5$  V DC) which can also be displayed on a meter.

**POWER:**

$23$  W ( $115$  V,  $0.2$  A,  $60$  Hz)

**WEIGHT:**

Approximately  $14$  kg with one sensor.

**VOLUME:**

$24,200$   $\text{cm}^3$  ( $1470$   $\text{in}^3$ )  
 [  $34$  cm ( $13.5$  in)  $\times$   $29$  cm ( $11.5$  in)  $\times$   $22$  cm ( $8.5$  in) for the monitor and  $36$  cm ( $14.25$  in)  $\times$   $8.3$  cm ( $3.25$  in)  $\times$   $8.3$  cm ( $3.25$  in) for the sensor ]

**PACKAGING/MOUNTING:**

Metal enclosed, rack or panel mounted.

**COST:**

\$1000

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:**

Slight repackaging of pH sensor head to accommodate rack or modular mounting. Modification of calibration cup is necessary for low-g operation.



## SHIPPING, STORAGE, HANDLING CONSIDERATIONS

None.

## ADDITIONAL COMMENTS:

LAZARAN (TM) or equivalent reference electrodes must be used for low-g operation. It may be possible to perform the calibration measurements on Earth before launch. Multi-sensor element heads can eliminate in situ cleaning. This item will be useful in the research areas of Biological Processing and Chemistry of Fluids. It must be capable of remote monitoring.

6.3.2 Modifications and Tests

- Electrical power conversion to 28VDC or 110V - 400 Hz.
- Amplifier/transmitter and indicator units may required modification or removal of outer covers and forced air cooling.
- Amplifier/transmitter and indicator units mounted to withstand 13.5g.
- Internally set controls in indicator unit may require resetting after reaching orbit due to vibration and acceleration of take-off.
- If cover over meter on indicator unit is made of glass, it should be replaced with plastic.
- Electrode mountings depend on experimental arrangement but must withstand vibration and 4.5g.
- Electrodes pH/millivolt relationship may be different in 0-g.
- Acceleration test at 3.0-g vibration tests, mountings test at 9.0g.
- Outgassing test of complete system.
- EMC tests.

6.3.3 Required Additional Information

- Cost of modifications and tests
  - a. factory
  - b. program contractor
  - c. NASA
- List of toxic, flammable, shatterable, or otherwise possibly dangerous materials; a complete list of construction materials is desirable.

#### 6.3.4 Commercial Utility Survey

ITEM:

pH Analyzer

TYPE:

Model 940  
Beckman Instruments, Inc.  
Process Instruments Division  
2500 Harbor Blvd.  
Fullerton, California 92634  
(714) 871-4848  
Mr. Gary Champion, Product Line Specialist

CONTACT:

Beckman Instruments, Inc.  
4115 Artesia Avenue  
Fullerton, California 92633  
(714) 521-3700  
Mr. Henry (Hank) Foster  
Field Sales Representative

ELECTRICAL:

- Input Power

Unit can be converted to either 28VDC or 110VAC 400 Hz, with 110VAC 400 Hz preferred. The wave form did seem to be a problem although some additional conversion might be necessary. It is estimated that a very modest conversion cost (ca \$200) would be incurred.

- EMC, EMI:

The unit is primarily solid state and is affected by transients to the extent of their occurrence only (i.e., no lasting effects). The unit does not generate EMI (picoampere operation for the most part) but is susceptible to RFI. Both TRW and Beckman did not think this would be a problem since coaxial shielding and metal enclosures are standard for field use and should shield the unit.

MECHANICAL:

- Modifications

Covers, rack mounting and placement of sensing head no problem. Since the unit is field adaptable, versatility in assembly and part placement has been maximized.

- Acceleration and Shock

No problems are anticipated for the stated acceleration, shock or vibration values. Some reinforcement of the control panel may be necessary.

## THERMAL:

- Cooling/Heating Requirements

Since the unit consumes very little power (23 watts), there are no cooling requirements assuming the amplifier, etc., are not close coupled to a hot spot.

## SAFETY:

- Construction Materials

Meter covers can be replaced by polycarbonate plastic. Sensor head is ruggedized, materials of construction are stainless, mild steel, aluminum, PC boards and IC units and glass electrodes. The electrodes are enclosed in a stainless head and should pose no hazard. The standard insulation on the wiring is PVC; this could be changed to Teflon by special order.

- Potential Hazards

No toxic or potentially flammable materials or other types of hazards are known to be present. If the electrodes break, they are contained and can not be released into the lab.

## OTHER:

- Company Modifications/Tests

Beckman is qualified and indicated their willingness to both modify the unit as necessary and test the end product (shock, vibration, thermal, etc.), then also indicated that TRW should contact Beckman's Advanced Technical Operations if any other Beckman produced equipment such as the Oxygen Analyzer will be considered. They are responsible for modifying a number of types of apparatus for Apollo use.

## 6.4 FREEZER/REFRIGERATOR

6.4.1 Commercial Item Survey Data - Freezer for storage and preservation of biological samples.

NAME:

Ultra-low temperature cabinet

SUPPLIER:

So-Low Environmental Equipment Co., Inc.  
Cleneay Industrial Central  
1743 Cleneay Avenue  
Cincinnati, Ohio 45212  
Phone: (513) 631-8903

MODEL NUMBER:

PR120-E

PERFORMANCE SPECIFICATIONS:

- Temperature control 1200 adjustable indicating type.  
Range -18°C (0°F) to -184°C (-120°F).
- Thermal capacity approximately 375 BTU's per hour at -166°C (-110°F).

DATA OUTPUT:

Not Applicable.

POWER:

115/208/230 volts, 60 cycle, 1/3 phase; 373 watts for each of  
(2) compressors.

WEIGHT:

200 kg (450 lbs.)

VOLUME:

Outside: 117 cm (46 in.), H-71 cm (28 in.), W - 102 cm (40 in.), L  
Chamber: 40 cm (16 in.), H - 45 cm (18 in.), W-76 cm (30 in.), L.

PACKAGING/MOUNTING:

- Cabinet all steel construction.
- Chamber is galvanized steel.
- Insulation 13 cm (5 in.) rigid non-settling type.
- Counter balanced lid with adjustable hinges and latch that can be locked. Also, furnished are beaded foam sub-lids.

COST:

Unknown.

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC :**

See accompanying sheets.

**SHIPPING, STORAGE, HANDLING CONSIDERATIONS:**

None.

**ADDITIONAL COMMENTS:**

See accompanying sheets.

**6.4.2 Commercial Item Survey Data - Refrigerator for storage and preservation of biological samples.**

**NAME:**

Ultra-low temperature cabinet

**SUPPLIER:**

So-Low Environmental Equipment Co., Inc.  
Cleneay Industrial Center  
1743 Cleneay Avenue  
Cincinnati, Ohio 45212  
Phone: (513) 631-8903

**MODEL NUMBER:**

PR50-G

**PERFORMANCE SPECIFICATIONS:**

- Temperature control 800 adjustable indicating type.
- Range ambient to -58°C (-50°F).
- Thermal capacity approximately 375 BTU's per hour at -40°C (-40°F).

**DATA OUTPUT:**

Not applicable.

**POWER:**

115/208/230 volts, 60 cycle, 1 or 3 phase; 746 watts for one compressor unit.

**WEIGHT:**

340 kg (750 lbs.)

**VOLUME:**

Outside: 120 cm (48 in.), H - 70 cm (28 in.), W - 165 cm (65 in.), L.  
Chamber: 48 cm (19 in.), H - 46 cm (18 in.), W - 140 cm (55 in.), L.

**PACKAGING/MOUNTING:**

- Cabinet all steel construction.
- Cabinet is galvanized steel.
- Insulation 13 cm (5 in.) rigid non-settling type.
- Counter balanced lid with adjustable hinges and latch that can be locked. Also furnished are beaded foam sub-lids.

**COST:**

Unknown.

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC:**

See accompanying sheets

**SHIPPING, STORAGE, HANDLING CONSIDERATIONS:**

None.

**ADDITIONAL COMMENTS:**

See accompanying sheets.

**6.4.3 Modifications and Tests**

- Electrical power conversion to 28VDC or 110V-400 Hz.
- Remove casters and install supports for mountings to withstand 9.0g.
- Compressors and refrigeration system with associated tubing and wires may require supports to withstand vibration and 3.0g.
- Lid requires positive lock-open position for handling samples.
- Install fan in lid for close temperature control, optional from So-Low.
- Compressor unit requires forced air cooling, optional with So-Low.
- If separate compartments with programmable temperature control are desired, modifications and optional equipment will be required. Programmable temperature control should be obtained by interfacing with the computer. So-Low provides separate compartments as an option. Packaging of samples must be adequate to withstand vibration and 3.0g.
- If a separate power source is desired to maintain temperature control for 48 hours in case of primary power failure, batteries with sufficient power to drive the compressor unit must be installed.

- Battery powered recording thermometers can be installed to provide maximum temperature readings for each compartment, independently of the primary temperature control systems. So-Low provides recording thermometers as an option, which would require modification to battery power.
- Interior lighting, optional from So-Low.
- Replace glass covers on optional recording thermometers with plastic.
- Acceleration test at 3.0g, vibration tests, mountings test at 9.0g.
- Outgassing test of complete system.
- EMC tests.

#### 6.4.4 Required Additional Information

- Reanalysis of the desirability of a dewar for storage down to -112°F (PR 120-E appears to be adequate, obviating the need for cryogenic fluids).
- Reanalysis of the following specifications previously:
  - Auxiliary power source for 48 hour period in case of failure of primary power source (other equipment may also require emergency power, e.g., the data acquisition system).
- Cost of modifications and tests.
  - a. factory
  - b. program contractor
  - c. NASA
- List of toxic, flammable, shatterable, or otherwise possibly dangerous materials; a complete list of construction materials is desirable.
- Cost of So-Low options: internal fan, external cooling fan for compressor unit, separate compartments, recording thermometers, interior lighting.
- Thermal information:
  - coefficient of performance
  - insulation used (or K-value)
  - working fluid
  - fan size and power required for compressor unit

#### 6.4.5 Commercial Utility Survey

ITEM: Freezer/Refrigerator for Biological Materials

TYPE: So-Low Environmental Equipment Co., Inc.  
Cleneay Industrial Center  
1743 Cleneay Avenue  
Cincinnati, Ohio 45212  
(513) 631-8903  
Mr. Walt Schum, President

CONTACT: Bob Milner and Associates  
Reseda, Ca.  
(213) 342-5181  
Mr. Bob Milner

#### ELECTRICAL:

- Input Power

All of the motors in the unit can be replaced by 110 VAC, 400 Hz units. So-Low could not comment on any potential derating factors that might be imposed by wave forms other than the conventional sine wave.

- EMC, EMI

Unit not appreciably affected by voltage transients. EMI generation will occur during compressor start up provided the 400 Hz motors exhibit the same characteristics as their present 60 Hz motors. Isolation transformers, shielding and filters should alleviate the problem.

#### MECHANICAL:

- Modifications

So-Low indicated that as long as any modifications that might be necessary do not involve extensive R&D effort, they would accommodate the changes. Minor changes of rack materials of construction, etc., are routinely performed.

- Acceleration and Shock

The contact was not aware of any testing that had been done regarding the ruggedness of the unit, other than the crating is modified depending where the unit is to be shipped. These units have been shipped all over the world by every type of transportation. Most likely the unit will have to be modified to take three axis loads. See Section 8 below.



## THERMAL :

## ● Cooling/Heating

Forced air cooling of the motors and compressors will be necessary. The coefficient of performance or duty cycle at temperature which impact these requirements depend on what temperature the unit is at and, how often the lid is opened. Since thermal convection is minimized in a low gravity environment, there may be minimal heat loss when samples are taken out or replaced. It was indicated that the unit will essentially maintain the set-point temperature for 24 - 48 hours with the unit shut off.

## SAFETY:

## ● Construction Materials

Materials of construction are primarily steel and aluminum. Wire insulation type and thermal insulation are unknown. Asbestos is used as the lid insulation sealant; this can be replaced by silicon rubber. Any glass covers (depending on desired options) can be replaced by polycarbonate plastic.

## ● Potential Hazards

The only potential hazard found to date is the type of refrigerant used. Because a dual compressor, cascade system is utilized to get to the low temperatures, low viscosity refrigerant R-170 is used, which is ethane. The limits of inflammability for ethane are between 3.00 to 12.50 v/o in air at STP. Thus the refrigerant should be changed in this unit.

## OTHER:

## ● Company Modifications/Tests

As mentioned previously, So-Low will provide modest modifications. The type of tests the company will or can perform is unknown.

## 6.5 PROCESS CONTROL AND DATA ACQUISITION UNIT

6.5.1 Commercial Item Survey Data - Process Control and Data Acquisition System which will be used in conjunction with all experiments.

NAME:

The system includes the following:

- Central Processor (620/L-102)
- Fixed Head Disc
- Teleprinter Terminal
- Interface Console
- Analog Input System
- Analog Output Module
- Analog Power Supply
- Adapter Software/Documentation
- VDM Standard Software

SUPPLIER:

VARIAN DATA MACHINES  
2722 Michelson Drive  
Irvine, California 92664  
Phone: (415) 493-4000

Sales Office:  
9001 S. Paramou      vd.  
Downey, California 90240  
Phone: (213) 927-2673

MODEL NUMBER:

A-410 (Complete System)

PERFORMANCE SPECIFICATIONS:

Central Processor:

- 16 - bit words
- 12,288 words of core storage

Fixed Head Disc:

- 61,000 word capacity
- Access to 150 applications programs
- Access to 300 data files

Teleprinter Terminal:

- 72 columns on printer

Interface Console:

- 16 analog inputs/8 analog outputs
- 1 word (16 bits) of digital input/output
- 8 control outputs/8 status inputs

- 2 manually variable analog sources
- 1 clock output
- 1 dc output at 5 volts
- 1 scan synchronizer input
- 2 input-output strobes

Analog Input System

- 16 channels in analog and digital multiplexer
- $\pm 10V$  signal input range
- 13-bit resolution
- 50 kHz sampling rate

Analog Output Module

- 2 channel digital - to - analog converter
- 8 status inputs and 8 control outputs
- 12 bit resolution
- $\pm 10V$  signal output range
- $\pm 0.012\%$  accuracy

DATA OUTPUT:

A unified, device-independent output structure providing for both analog and digital outputs; included as a minimum is a two-channel digital-to-analog converter with 8 status inputs and 8 control outputs.

POWER:

110 Volts AC, 60 Hz.

WEIGHT:

Unknown.

VOLUME:

Unknown.

PACKAGING/MOUNTING:

Cabinet.

COST:

\$25,975

MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC.

See accompanying sheets.

## SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

## ADDITIONAL COMMENTS:

See accompanying sheets.

6.5.2 Modifications and Tests

- Electrical power conversion to 28 VDC or 110 V to 400 Hz.
- Teleprinter requires separate mounting; all other units can probably be mounted together with provided cabinet to withstand vibration and 3.0 g.
- Forced air cooling may be required for teleprinter.
- Disk storage may require modifications (disk supports, read-write heads, wires) to withstand vibration and 3.0 g.
- Core memory may require shock and vibration mounting.
- Glass cover over CRT replaced with plastic.
- Acceleration test at 3.0 g, vibration tests, mountings test at 9.0 g.
- Outgassing test of complete system.  
EMC tests.

6.5.3 Required Additional Information

- Cost of modifications and tests:
  - (a) Factory
  - (b) NASA
- List of toxic, flammable, shatterable, or otherwise possibly dangerous materials. A complete list of construction materials from the manufacturer would be desirable.
- Lubricants used in disc storage, clocks and teleprinter.

## 6.6 CHEST - GENERAL PURPOSE ENCLOSURE

6.6.1 Commercial Item Survey Data - Chest-general purpose enclosure for use with vacuum and controlled atmospheres.

NAME:

Chest-type furnace enclosure.

SUPPLIER:

SATEC Systems Inc.  
9550 Flair Drive, Suite 406  
El Monte, California 91731  
Phone: (714) 579-7830

MODEL NUMBER:

VC-208

PERFORMANCE SPECIFICATIONS:

- Vacuum capability:  $1.3 \times 10^{-6}$  N/m<sup>2</sup> ( $1.8 \times 10^{-10}$  psi).
- Enclosure construction: Double-wall with water cooling of all surfaces.
- Door: Full length front opening.
- Viewing port: 1.3 cm (0.5 in.) inside diameter, rear of chest and side of chest.
- Flange: 15 cm (6 in.) inside diameter on lower chest for connecting vacuum pumping unit.
- Flange: 10 cm (4 in.) inside diameter on upper chest side for instrumentation lead-in.
- Flange: Top and bottom.
- Flange vacuum sealing: Metal-to-metal seals.

DATA OUTPUT:

Not applicable.

POWER:

Not applicable.

WEIGHT:

Approximately 45 kg (100 lb).

VOLUME:

97,100 cm<sup>3</sup> (5880 in<sup>3</sup>)  
[38 cm (15 in.) x 71 cm (28 in.) x 36 cm (14 in.)]

PACKAGING/MOUNTING:

Suitable for direct mounting.

COST:

Price quoted after application is made.

**MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC.:**

None.

**SHIPPING, STORAGE, HANDLING CONSIDERATIONS:**

None.

**ADDITIONAL COMMENTS:**

Model VC-208 is normally supplied with standard heating elements and radiation shields to provide hot zones with 7.6 cm (3 in.) inside diameter and 15 cm (6 in.) long. This is considered to be larger than necessary and a more reasonable size of 2.5 cm (1 in.) diameter by 10 cm (4 in.) long could be provided.

**6.6.2 Modifications and Tests**

- Mounting adapter required to withstand 9.0 g.
- Excluded heating element is too large; 3000°C would require 40 kW
- Three (3) additional 1.5 in ID view ports at top, bottom and one side required (SATEC will modify).
- Feedthrough for inert gas required.
- Mounting test at 9.0 g. Acceleration test at 30 g and vibration tests with heating and contactless position control elements installed.
- Outgassing test at 3000°C sample temperature.
- EMC tests during sample processing.

**6.6.3 Required Additional Information**

- Cost of modifications and tests:
  - (a) Factory
  - (b) Program contractor
  - (c) NASA
- List of toxic, flammable, shatterable or otherwise possibly dangerous materials. A complete list of construction materials is desirable.
- Cost from SATEC for three additional 1.5 in ID view ports and on inert gas feedthrough.
- Thermal:
  - Water flow rates
  - Outlet/inlet temperatures

## 6.7 HOT WALL FURNACE

6.7.1 Commercial Item Survey Data - Hot wall furnace (1800°C) for use with vacuum, inert gas, reducing gas and oxidizing environments.

NAME:

High vacuum, high temperature furnace.

SUPPLIER:

Astro Industries, Inc.  
606 North Olive Street  
Santa Barbara, California 93101  
Phone: (805) 963-3461

Key Contacts: John L. Wiester - President  
James R. Wilson - Engineering Manager

MODEL NUMBER:

1100 V - 1060-M1

PERFORMANCE SPECIFICATIONS:

- Hot zone dimensions - 2.5 cm (1 in.) diameter by 15 cm (6 in.) long
- Maximum sustained temperature - Depends upon atmosphere and heating element construction.
- Time to temperature - Ten minutes or less.
- Heating element - Molybdenum mesh with molybdenum sheet radiation shields.
- Operation environments - Vacuum, inert gas and reducing atmospheres (oxidizing atmospheric with oxide muffle tubes).
- Observation - Shuttered radial viewport 1.7 cm (0.65 in.) diameter fused quartz. Gas depog inlet for inert gas operation. Additional path optional.
- Instrumentation - One radial instrumentation port standard.
- Access - Top and/or bottom.
- Maintenance - Heating element and shield package can be removed and replaced within 60 minutes without special tools.
- Cooling - Water cooled; integral water channels in shell; power feedthroughs and bulkheads. Requires  $4 \times 10^5 \text{ N/m}^2$  (60 psi) across system.

DATA OUTPUT:

Temperature.

POWER:

Refractory heating elements typically require voltages of about 8 to 10 V (see attached sheet for power).

WEIGHT:

45 kg (100 lb) - furnace only.

VOLUME:

21,700 cm<sup>3</sup> (1350 in<sup>3</sup>).

[24 cm (9.5 in.) diameter by 48 cm (19 in.) long]

PACKAGING/MOUNTING:

Vertical or horizontal mounting.

COST:

\$3100 (furnace only).

MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC.:

Normally the specimen to be heated is placed on a support plate or pedestal. For zero-G performance, a positive means of specimen support will be required (such as a clamp-type fixture) for the encapsulated samples.

SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

Some care will be required for fired tungsten heating elements.

ADDITIONAL COMMENTS:

None.

6.7.2 Modifications and Tests

- Electrical power conversion to 28 VDC or 110 V - 400 Hz.
- Replace meter cover glass on power supply with plastic.
- Remove outer cover of power supply; forced air cooling may be required.
- Base plate on which power supply and furnace rod support are mounted must be secured to withstand 9.0 g.
- Internal power supply wires must be secured to withstand vibration and 3.0 g.



- Furnace mounting on single rod may require modification to withstand 9.0 g.
- Molybdenum mesh heating element may require packaging to prevent damage from shock and vibration.
- SCR may require shielding for EMC.
- Automatic control is option - sensing, controlling, recording and programming. These features should be adapted to the computer system.
- Furnace power, gas and water cooling lines must be secured to withstand vibration and 3.0 g.
- Pump down should be by means of space vacuum, with coupling to furnace by provided water cooled stainless steel elbow with TC and ionization gages and high vacuum valve.
- A hydrogen gas collection system must be provided or the gas eliminated to space, if a hydrogen atmosphere is used.
- If a liquid nitrogen cold trap is desired, a completely internal loop must be used.
- The work support plate provided at one end of the furnace must be modified to grip the specimen in 0 g.
- Acceleration test at 3.0 g, vibration tests, mountings test at 9.0 g.
- Outgassing test of complete system.
- EMC tests.

#### 6.7.3 Required Additional Information

- Cost of modifications and tests.
  - (a) Factory
  - (b) Program contractor
  - (c) NASA
- List of toxic, flammable, shatterable or otherwise possibly dangerous materials. A complete list of construction materials is desirable.
- Cost of optional sight and instrumentation ports.
- Thermal
  - . Water flow rate

## 6.8 DYE LASER/FLASH LAMP

6.8.1 Commercial Item Survey Data - Dye laser/flash lamp for use in many different areas: free radical generation, surface damage threshold determination and holographic microscopy.

## NAME:

Chromabeam Organic Dye Laser System

## SUPPLIER:

Synergetics Research Inc.  
University Park Plaza  
741 Alexander Road  
Princeton, New Jersey 08540

Phone: (609) 452-8980

## Local Representatives:

Johnson Associates  
5715 W. Manchester Avenue  
Los Angeles, California 90045

Phone: (213) 641-0400

## MODEL NUMBER:

1050

## PERFORMANCE SPECIFICATIONS:

- . Energy output: to 250 mj/pulse
- . Repetition rate: to 3 ppm - manual
- . Amp
- . Spectral output: When operated broadband, a variety of dyes can be used which emit overall parts of the visible spectrum. With the optional grating mount tuning from 4300 - 6500 Å is possible.

## DATA OUTPUT:

None.

## POWER:

115 volts, 60 hertz, 2 amps - 230 watts

## WEIGHT:

Laser Head	- 13.5 kg (30 lb)
Electronics Console	- 18 Kg (40 lb)
Dye Flow Unit	- 4.5 Kg (10 lb)
TOTAL	36 Kg (80 lb)

## VOLUME:

## Laser Head:

67 cm (29 in.) x 25 cm (10 in.) x 38 cm (15 in.)

## Electronics Console:

46 cm (18 in.) x 46 cm (18 in.) x 35 cm (14 in.)

## Dye Flow Unit:

33 cm (13 in.) x 13 cm (5 in.) x 20 cm (8 in.)

## PACKAGING/MOUNTING:

Bench mounting.

## COST:

\$2595

## MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC.:

See accompanying sheets.

## SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

## ADDITIONAL COMMENTS:

See accompany sheets.

6.8.2 Modifications and Tests

- Electrical power conversion to 28 VDC or 110 V - 400 Hz.
- Laser head and flashlamp may require packaging to avoid damage from vibration and 3.0 g.
- Replace glass cover over meter on electronic console with plastic.
- All units should be modified for rack mounting to withstand 9.0 g and have cabinet covers removed if no specific function is served.
- External and internal wires and dye circulation lines should be secured to withstand vibration and 3.0 g.
- Flashlamp, dye circulation unit and electronic console will require forced air cooling.
- Spark gap and capacitor bank in electronic console will require shielding to avoid EMC problems.
- Safety interlock between laser head and high voltage (0-25 KV) in electronic console must be modified appropriately for mounting modifications.
- Protection from high intensity light from laser and flashlamp

must be incorporated.

- Acceleration test at 3.0 g; vibration tests, mountings test at 9.0 g.
- Outgassing test of complete system.
- EMC tests.

### 6.8.3 Required Additional Information

- Cost of modifications and tests:
  - (a) Factory
  - (b) Program contractor
  - (c) NASA
- List of toxic, flammable, shatterable or otherwise possibly dangerous materials; a complete list of construction materials is desirable.
- Cost of custom higher power flashlamps.

## 6.9 HIGH VOLTAGE POWER CONDITIONER (5 KV)

6.9.1 Commercial Item Survey Data - Variable high voltage power conditioner (DC) for stationary and continuous flow electrophoretic columns.

NAME:

CAMAG Power Supply.

SUPPLIER:

TRANSIDYNE General Corp.  
462 South Wagner Road  
Ann Arbor, Michigan 48103  
Phone: (313) 663-9329

MODEL NUMBER:

2815

PERFORMANCE SPECIFICATIONS:

- . Voltage output - 0 to 5 KV DC
- . Current output - 200 mA
- . Ripple (or other fluctuations) - less than 1 mV rms (root mean square)
- . Accuracy (voltage output) -  $\pm 0.1\%$

DATA OUTPUT:

Data output is voltage and current when the electrophoretic column is operating.

POWER:

1100 W (115 V - 60 Hz) at maximum output (assuming 90% efficiency).  
Intermittent operation.

WEIGHT:

Approximately 20 kg (44 lb).

VOLUME:

Approximately 12,000 cm<sup>3</sup> (770 in<sup>3</sup>)  
[30 cm (12 in.) x 20 cm (8 in.) x 20 cm (8 in.)]

PACKAGING/MOUNTING:

Metal enclosed, counter top mounting.

COST:

\$1,475

MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC.:

Mounting configuration will probably have to be modified for biological process module or system. Electrical interlocks and surge overload cut-out monitor are necessary for personnel safety. Analog voltage and current readout is required to establish correct operating conditions. Electrical interference isolation from main power bus may be required.

SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

ADDITIONAL COMMENTS:

This solid state device may find applications in other research processes requiring high voltages at moderate currents (e.g., crystal growth and purification).

6.9.2 Modifications and Tests

- Electrical power conversion to 28 VDC or 110 V - 400 Hz.
- Modifications for remote programming and current/voltage monitor readout for data acquisition (readout might be considered to belong to the external circuit).

- Modification of safety case to allow forced air cooling.
- Rack mounting, wires secured to withstand vibration and 3.0 g.
- Replace glass meter covers with plastic.
- Acceleration test at 3.0 g; vibration tests, mountings test at 9.0 g.
- Outgassing test of complete system.
- EMC tests.

#### 6.9.3 Required Additional Information

- Cost of modifications and tests:
  - (a) Factory
  - (b) NASA
- List of toxic, flammable, shatterable or otherwise possible dangerous materials; a complete list of construction materials is desirable.
- Thermal
  - . Maximum allowable operational temperature of subelements.

#### 6.9.4 Commercial Utility Survey

##### ITEM:

High Voltage Power Conditioner

##### TYPE:

Model DCR 600-.25A\*  
 Raytheon Company  
 Sorenson Power Supplies  
 676 Island Pond Road  
 Manchester, New Hampshire 03103  
 (603) 668-1600

##### CONTACT:

Instrument Specialists, Inc.  
 1109 S. Central Avenue  
 Glendale, California 91204  
 (213) 245-9404  
 Mr. Al Beal

\*This unit was chosen over the originally specified CAMAG unit (TRANSIDYNE) since the new unit meets or exceeds performance requirements and does not seriously impact weight, volume or power constraints.

## ELECTRICAL:

## ● Input Power

The unit can be converted to either 28 VDC or 110 VAC 400 Hz. One-hundred and ten VAC 400 Hz is preferred since conversion costs, power demand and additional equipment (DC to AC conversion) are minimized. The wave form can be modified; again, additional option equipment may be required to insure performance and EMC/EMI requirements if the 400 Hz is not sine wave. Unit may be derated if the frequency deviates more than approximately  $\pm 5\%$ .

## ● EMC, EMI

EMC is no problem. The unit has a 30 ms transient response time which is adequate for the intended operation. EMI is no problem. The unit meets MIL-I-26600 and MIL-I-6181D RFI requirements and is not susceptible to EMI.

## MECHANICAL:

## ● Modifications

Covers and rack mounting are standard options. Sorenson has had a great deal of experience in modification of off-the-shelf units to meet customer requirements without resorting to a fully customized design. This includes conformal coatings, fungus-proof paint, special input/output receptacles, etc. The unit is remotely programmable either in a voltage or current mode so no modifications are necessary.

## ● Acceleration and Shock

No problems are anticipated for the stated acceleration, shock or vibration levels. Remounting and mechanical reinforcement of the transformers may be necessary depending on unit location and placement.

## THERMAL:

## ● Cooling/Heating Requirements

Forced air cooling will be necessary. Transidyne stated that some modification of the power supply cover may be necessary, which might influence RFI output, but he felt that this would be minor and a design could be worked out.

## SAFETY:

## ● Construction Materials

Meter covers can be replaced by polycarbonate plastic.

Materials of construction are mild steel, aluminum, PC boards, sealed transformers and solid state devices. Most (if not all) of the wiring is Teflon insulated. Any type wire can be installed if it is compatible with the required voltage breakdown characteristics.

## ● Potential Hazards

No toxic or potentially flammable materials are known to be present in the instrument. Electrical shock hazard is minimized since the instrument incorporates interlocks and voltage, current and thermal overload trips as well as a "zero start" interlock, although the last item can be bypassed if necessary.

## 6.10 IR PYROMETER

6.10.1 Commercial Item Survey Data - IR pyrometer for use in noncontact temperature measurement and control.

## NAME:

Modline

## SUPPLIER:

Ircon  
207 Lawrencewood Center  
Niles, Illinois 60648  
Phone: (312) 967-5151  
  
Local Representative  
Hy Hacker Associates (Hy Hacker)  
454 South Willaman Drive  
Los Angeles, California  
Phone: (213) 272-0429

## MODEL NUMBER:

2000 Series

## PERFORMANCE SPECIFICATIONS:

- Temperature ranges: 40 - 2000°C (104-5400°F) dependent on head and indicator.
- Spectral response: 0.70 to 0.97  $\mu\text{m}$ .



- Calibration accuracy:  $\pm 1\%$  full scale temperature or  $\pm 5^{\circ}\text{C}$  ( $\pm 10^{\circ}\text{F}$ ), whichever is greater.
- Repeatability:  $\pm 0.3\%$  full scale temperature or  $\pm 0.3\%$  full scale temperature.
- Response time at meters: 95% full scale input within 1 s.
- Indicator/controller ambient temperature range: 10 to  $65^{\circ}\text{C}$  (50 to  $150^{\circ}\text{F}$ ).
- Sensing head ambient temperature range:  $-32$  to  $94^{\circ}\text{C}$  (0 to  $200^{\circ}\text{F}$ ).

DATA OUTPUT:

0 - 100 mV DC (100  $\Omega$  source) plus a variety of other outputs.

POWER:

15 W maximum (115/230 V  $\pm 10\%$  - 50/60 Hz).

WEIGHT:

Head 7 kg (15 lb).

VOLUME:

Head - 6750  $\text{cm}^3$  (435  $\text{in}^3$ ).

Indicator/controller - 13,500  $\text{cm}^2$  (870  $\text{in}^3$ ).

PACKAGING/MOUNTING:

Head bolted near or on experiment enclosure controller - rack mount.

COST:

With digital display without control - \$1800; with 3 mode proportional control and deviation meter - \$2400.

MODIFICATIONS FOR ZERO-G PERFORMANCE, SAFETY, RELIABILITY, ETC.:

None.

SHIPPING, STORAGE, HANDLING CONSIDERATIONS:

None.

ADDITIONAL COMMENTS:

Electronics may be modified to produce a wide range of temperature measurements on the same instrument.

6.10.2 Modifications and Tests

- Electrical power conversion to 28 VDC or 110 V - 400 Hz.

- Removal of outer covers.
- Replacement of indicator meter glass by plastic.
- Rack mounting of indicator unit.
- Sensing head mounted as required for experiment.
- Printed circuit boards (G-10 epoxy fiberglass) may require additional support to withstand 3.0 g and vibration tests.
- Forced air cooling may be required.
- A minimum of 6 sensing heads will be required to cover the temperature range - 17.8 to 3000°C.
- Acceleration test at 3.0 g, vibration tests, mountings test at 9.0 g.
- Outgassing test of complete system.
- EMC tests, perhaps.

6.10.3 Required Additional Information

- Cost of modifications and tests:
  - (a) Factory (IRCON will quote on special modifications).
  - (b) NASA
- List of toxic, flammable, shatterable or otherwise possibly dangerous materials. A complete list of construction materials from the manufacturer would be desirable.

6.10.4 Commercial Utility Survey

ITEM:

IR Pyrometer

TYPE:

Modline Series  
IRCON  
207 Lawrencewood Center  
Niles, Illinois 60648  
(312) 967-5151

CONTACT:

Robinson Technical Associates  
2991 Grace Lane  
Costa Mesa, Calif. 92626  
(714) 557-1622  
Mr. Ivan Robinson

**ELECTRICAL:**

## ● Input Power

Probably can be converted to 110 VAC 400 Hz utilization. Power form (square wave or modified sine wave) was not mentioned.

## ● EMC, EMI

Unit not appreciably affected by voltage transients such as spikes, etc. Temperature readout portion of unit does not generate EMI. If controller portion of unit is used, EMI generation would depend on type of controller. SCR's using zero voltage firing to control Nichrome Heaters or other low TCR heater materials should not cause EMI; tungsten heaters would. For very high (2500°C) temperatures, saturable core reactors should be used, at a weight penalty over SCR's.

**MECHANICAL:**

## ● Modifications

Covers, rack mounting, placement of sensor head no problem. The use of the sensor head as a viewport by gasketing directly to equipment such as a Chest-General Purpose Enclosure was not mentioned. Rack mounting may impart cooling requirements, see Section 6.1.

## ● Acceleration and Shock

A 3.0 g acceleration and a 9.0 g vibration shock probably won't be a problem by potting IC components and remounting transformers, etc.

**THERMAL:**

## ● Cooling/Heating Requirements

Forced air cooling is required for the indicator/controller unit. Sensor head operates without any cooling, unless it can be used as indicated in Mechanical Modifications above, in which water cooling would be required.

**SAFETY:**

## ● Construction Materials

Meter covers can be replaced by polycarbonate plastic (e.g., G. E. Lexan). Sensor head is ruggedized. Materials of construction are aluminum, mild steel, epoxy/fiberglass and IC

units primarily. Wire insulation type unknown.

- Potential Hazards

No toxic or easily flammable materials or other type of potential hazards are known to be present. A potential electrical hazard may exist if the unit is to be used with the proportional controller. By proper design and rack mount construction, this hazard should be eliminated.

OTHER:

- Company Modifications/Tests

Mr. Robinson will contact IRCON (Mr. John Oliver at their San Jose facility) to determine how much modification IRCON will do (e.g., replace wiring, remount, etc.) and approximate cost. The ability of IRCON to do testing such as vibration, outgassing, etc., is not known.

- Unit Use

Because of the widely varying types of materials to be processed, more than one type of indicator/controller unit may be needed since emittance calibration is done in the unit, not in the sensor head. However, all the MODLINE series are essentially the same and the above comments apply to any of the units.

## 7. REFERENCES

## 7. REFERENCES

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